

Kennedy Space Center
Launch Equipment Test Facility
(LETF)
Capabilities
2015



KSC Launch Equipment Test Facility Overview

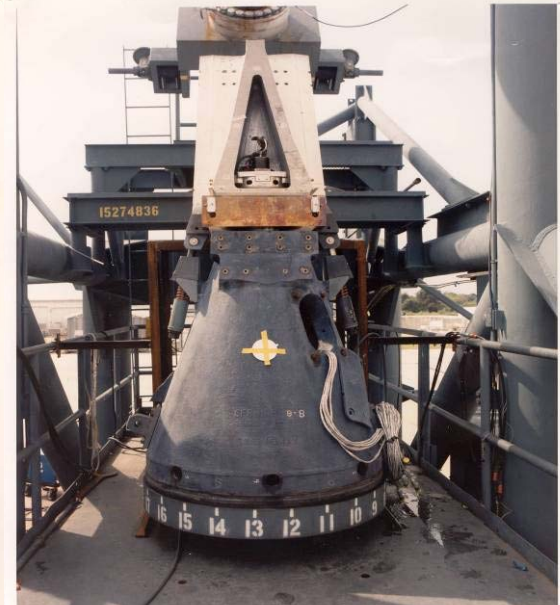
- ◆ The Launch Equipment Test Facility (LETF) supports a wide spectrum of testing and development activities.
- ◆ This capability was originally established in the 1970's to allow full-scale qualification of Space Shuttle umbilicals and T-0 release mechanisms.
- ◆ The LETF has leveraged these unique test capabilities to evolve into a versatile test and development area that supports the entire spectrum of operational programs at KSC.



**Cryogenic
Testing**



TSM Testing



**SRB Hold Down Post
Calibration Tests**



KSC Launch Equipment Test Facility Overview (continued)



Vehicle Motion Simulator



Umbilical System Prototype Development



Cryogenic Component Testing



Structural Testing/Proof Load Testing



Rapid Manufacturing/Prototype Capability



Sample Past Test Programs in the LETF

- ◆ Hold Down Post Calibration
- ◆ Load Testing of SRM Beams
- ◆ ET Vent QD Shroud Testing
- ◆ BSM Aeroheat Shield Testing
- ◆ NESC Stud Hang-up Testing
- ◆ Crawler Shoe Testing
- ◆ ELV Payload Fairing Test
- ◆ LOX Pump Testing
- ◆ Blast Debris Containment Device
- ◆ Payload Ground Handling Mechanism
- ◆ OAA Actuator Testing
- ◆ ETV Energy Absorber Test
- ◆ Failsafe Jackscrew Test
- ◆ Payload Transporter
- ◆ Autocoupler Testing
- ◆ Delta IV Swing Arm
- ◆ Delta IV Disconnect Testing
- ◆ Delta IV Hydrogen Entrapment
- ◆ Fluid/Valve Component Qualification Tests
- ◆ Constellation IU/LH2 Umbilical Tests
- ◆ X-33 Umbilical Testing
- ◆ Composite Nose Cone Testing
- ◆ 2 inch Cryo Replenish Valve Testing
- ◆ SSPF NH3 Servicer Qualification
- ◆ HDP Alternate Shim Material Testing
- ◆ ET Vent TO Lock Testing
- ◆ 17 Inch Disconnect Hydrogen Leak Dispersion Test Program
- ◆ SRB Joint Heater Umbilical Testing
- ◆ LO2 TSM Testing
- ◆ LH2 TSM Testing
- ◆ Centaur Rolling Beam Testing
- ◆ ET Vent Testing
- ◆ GOX Vent Arm Testing
- ◆ OAA Test
- ◆ Titan H/W Proof Loading
- ◆ Special Power Supply Development for the MLP
- ◆ NESC Pyrotechnic Valve Testing
- ◆ Hypergol Ball Valve Qualification



Hold Down Post Test Fixture

The Hold Down Post (HDP) Test Fixture is a static test structure used to simulate loading conditions on the Hold Down Post for calibration of the HDP strain gages and special testing of HDP/SRM interfacing hardware. The special testing includes spherical bearing moment, epon shim and HDP blast container testing.

Load Capacity:

The test fixture combined loading capabilities are as follows:

Combination I - Vertical compression max load of 2000 kips while applying a horizontal tension max load of 610 kips.

Combination II - Vertical tension max load of 875 kips while applying a horizontal tension max load of 300 kips.

Moment Load - Max 250 kips horizontal tension applied independently.





600 Ton Test Fixture

The 600 Ton Test Fixture is a multi-purpose proofloading apparatus. Test articles can be tested in either the vertical or horizontal direction. They can also be tested in either tension or compression. The versatility of the test fixture makes it possible to test a wide variety of large scale GSE components that require periodic proofloading to remain in service. It can also be used to test objects to failure to better understand their performance. The test fixture has a long history of providing support to the Shuttle program and other customers at KSC.

The 600 Ton Test fixture is capable of testing hardware vertically up to 23ft tall, 20'-9" wide at a capacity of 600 tons (tension and compression). The fixture is capable of testing hardware horizontally up to 66ft long, 20'-9" wide at a capacity of 400 tons (tension and compression). The 600 Ton Test Fixture can be used to test a variety of test article. Typical GSE that is tested include slings and lifting beams.





Water Flow Test Loop

The Water Flow Test Loop is used to verify performance of various fluid components including valves, pumps, and flow meters. Water Flow Test Loop is a set of closed, independently operated, concentric flow loops which are supplied from a pair of stainless steel tanks. Each loop consists of a large main line and a smaller bypass line. The loops are supplied through a common feed line and return through a common return line. Flow is induced by means of Variable Frequency Driven pumps.

Capabilities and Specifications:

- Tank Capacity: 5200 Gallons Each (Total 10,400)
- Maximum Tank Pressure: 125 psig
- Maximum Ullage Pressure: 110 psig
- Large Pump Maximum Flow Rate: 1700 GPM
- Small Pump Maximum Flow Rate: 400 GPM
- Large Pump Maximum Discharge Pressure: 300 psig
- Small Pump Maximum Discharge Pressure: 130 psig
- Large Pump Maximum RPM: 3450
- Small Pump Maximum RPM: 3350

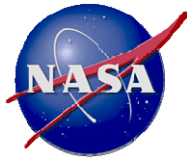




Vehicle Motion Simulator

- ◆ **VMS simulates all of the motions that a launch vehicle will experience from the time of its roll-out to the launch pad, through roughly the first ½ second of launch.**
 - Enables the development and qualification testing of umbilical systems in both pre-launch and launch environments and launch vehicle access arms in a pre-launch environment.
 - Verify operations procedures, clearances, disconnect systems performance & margins, and vehicle loads through processing flow motion excursions.





Vehicle Motion Simulator

◆ Access arms

- Horizontal motion only
 - Simulate excursions during vehicle processing flow
- Launch vehicle mock-ups
- High frequency (up to 2 hz), small amplitude motion (to roughly 2-1/2")
- Test durations replicate vehicle roll-out time (8-12 hrs)

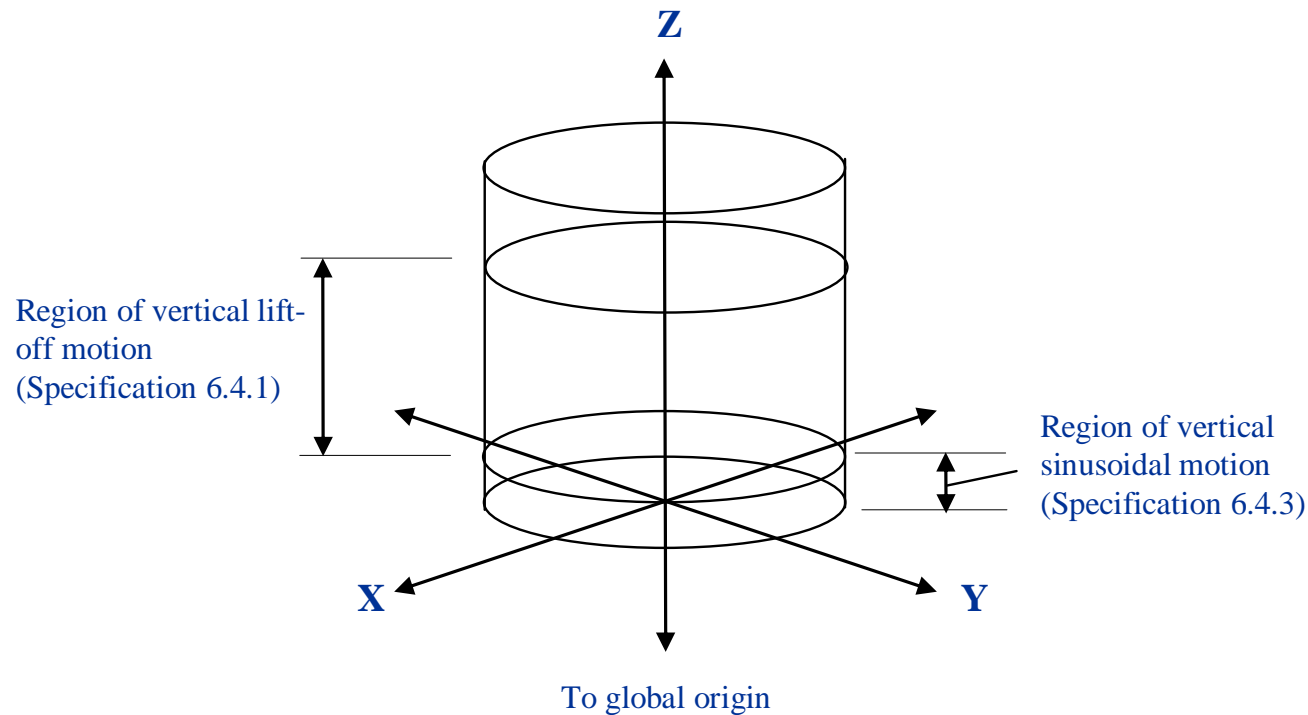
◆ Umbilical

- Horizontal motion
- Vertical motion
 - Launch event (with or without horizontal trajectory component)
 - Horizontal and/or vertical motion prior to launch event
 - Vertical motion to simulate cryo-shrinking
 - Verify clearances as umbilical separates



Vehicle Motion Simulator

◆ Motion envelope:

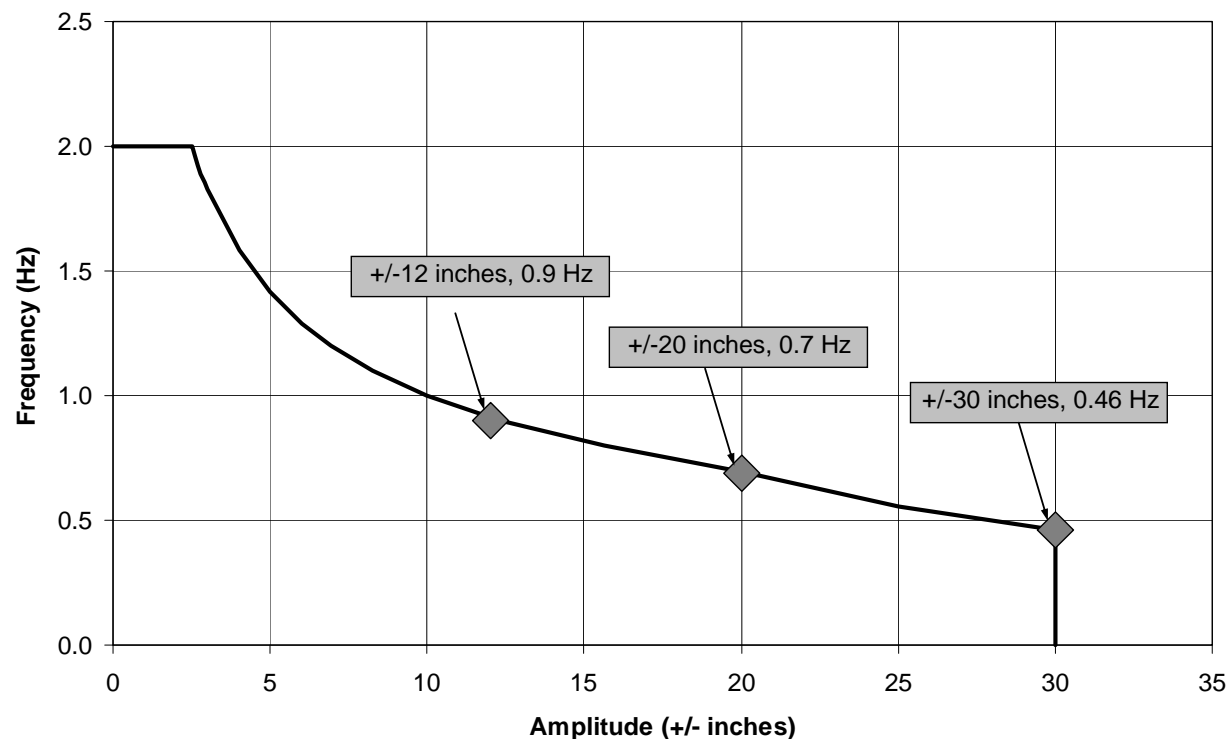


- ◆ Upwards acceleration for umbilical tests are constant, net 1.2g through 48 inches.
- ◆ Can limit travel to any reduced size envelope.



Vehicle Motion Simulator

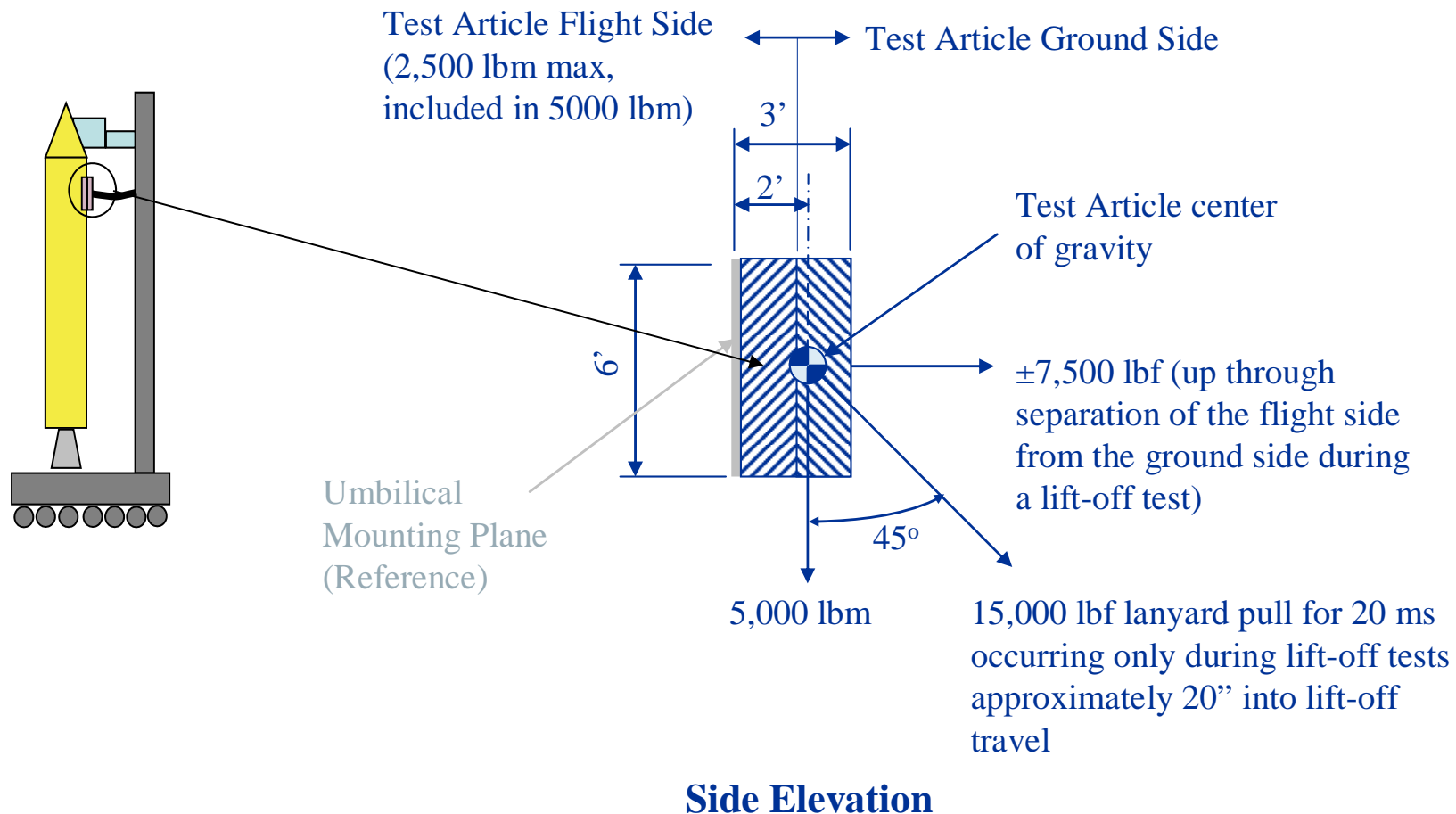
- ◆ Horizontal motion is possible anywhere below the curve defined (largely) by constant 1.0g sinusoidal motion.





Vehicle Motion Simulator

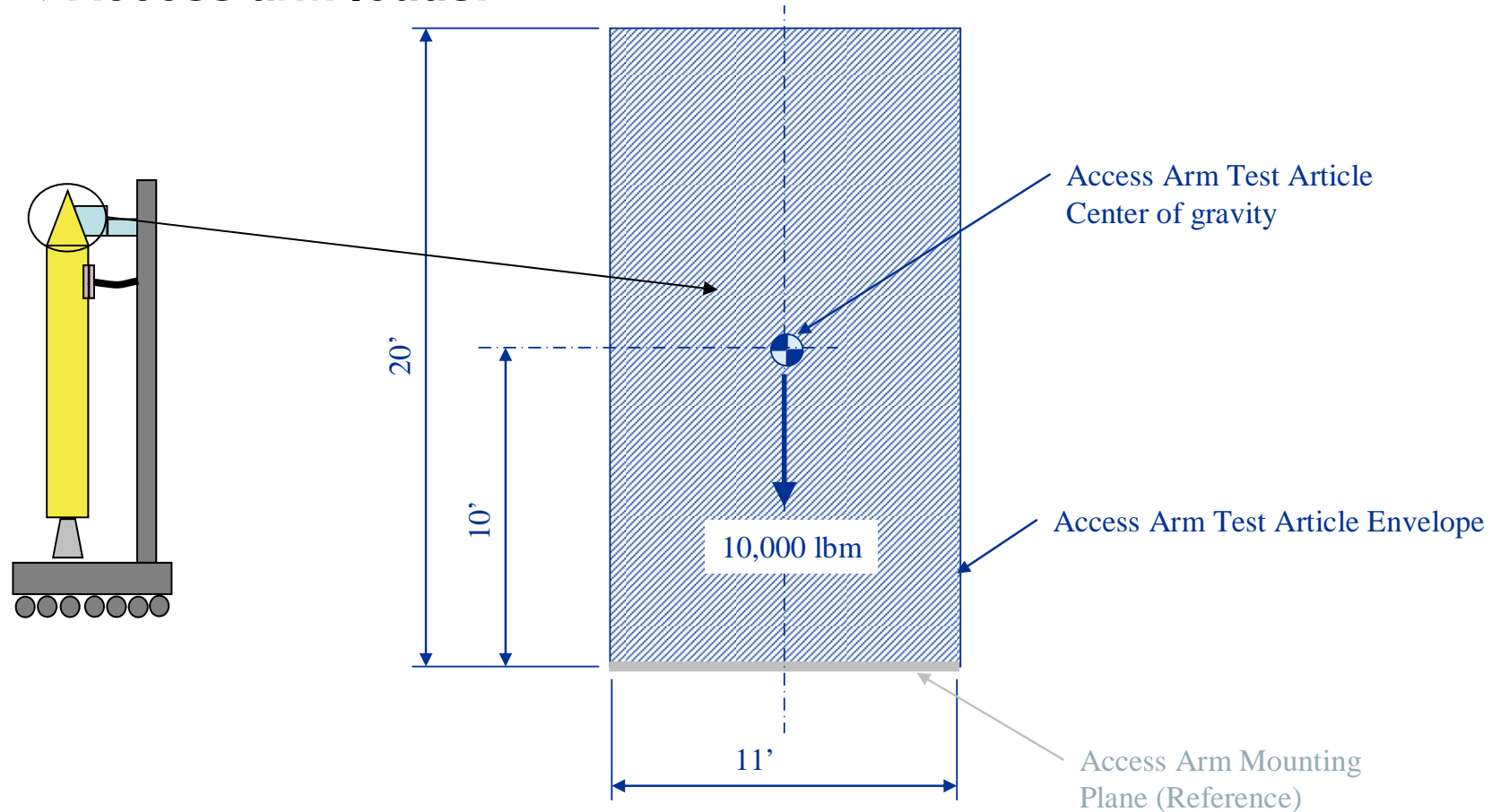
◆ Umbilical loads:





Vehicle Motion Simulator

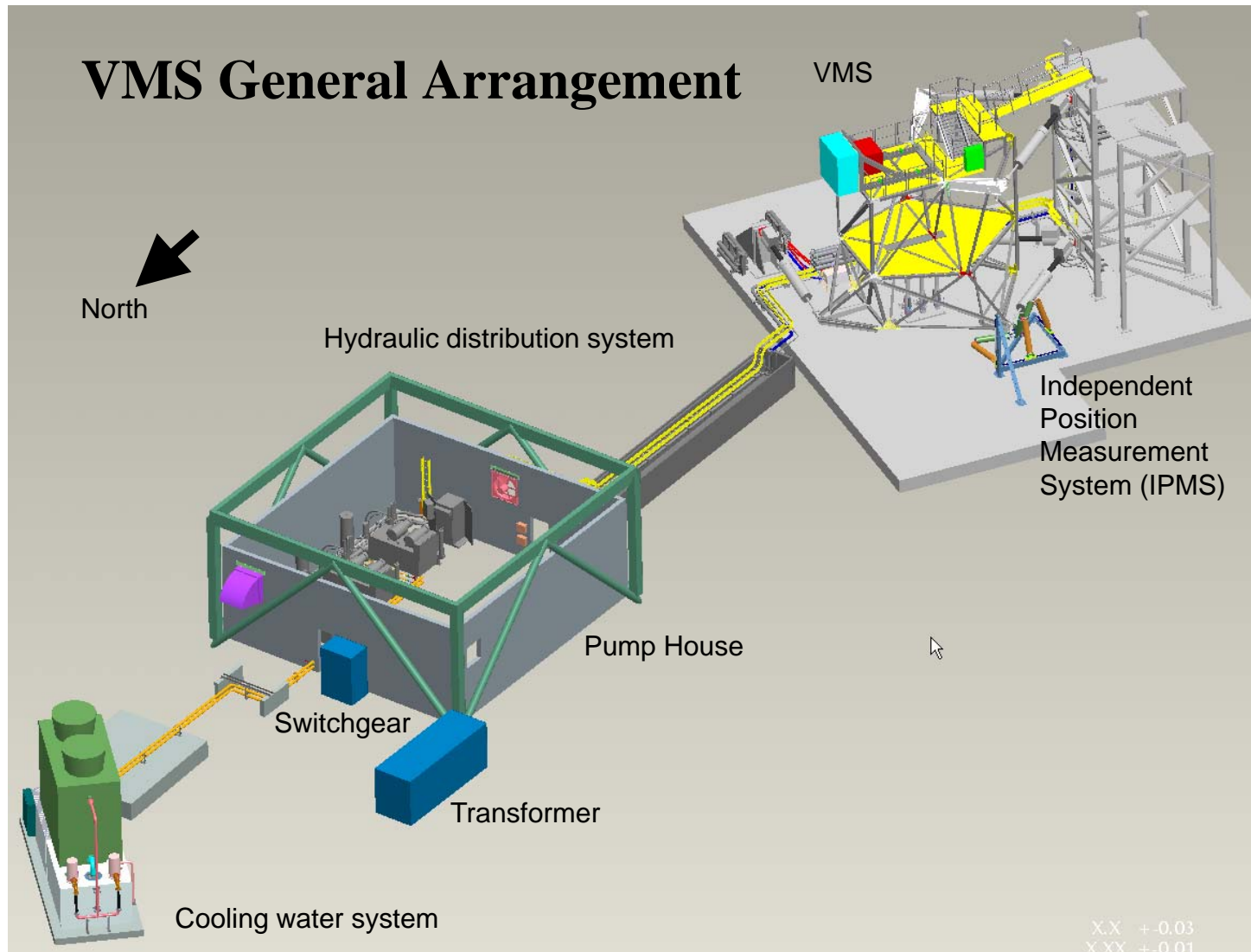
◆ Access arm loads:



Elevation View



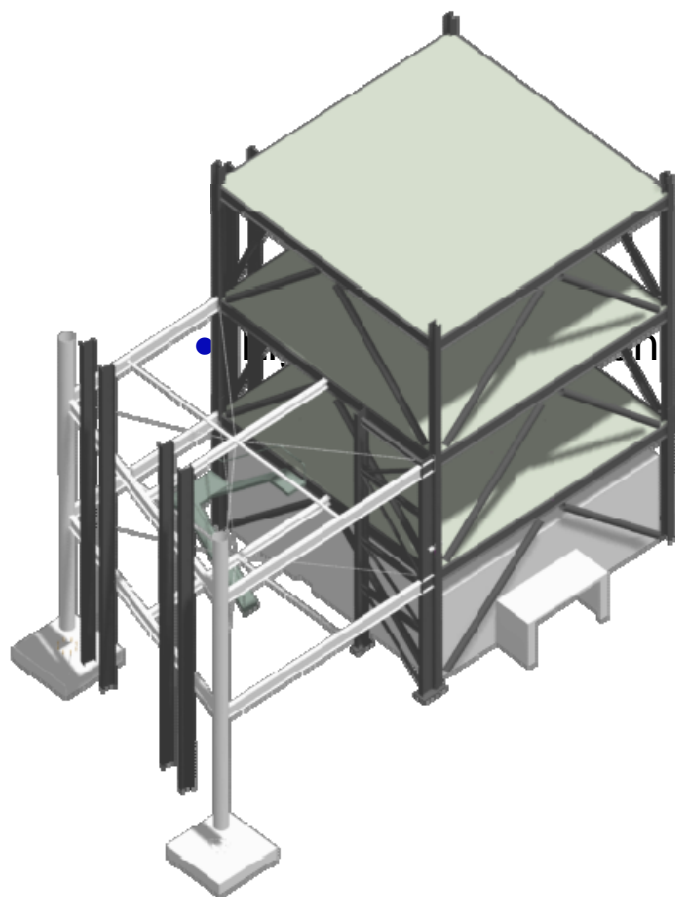
Vehicle Motion Simulator



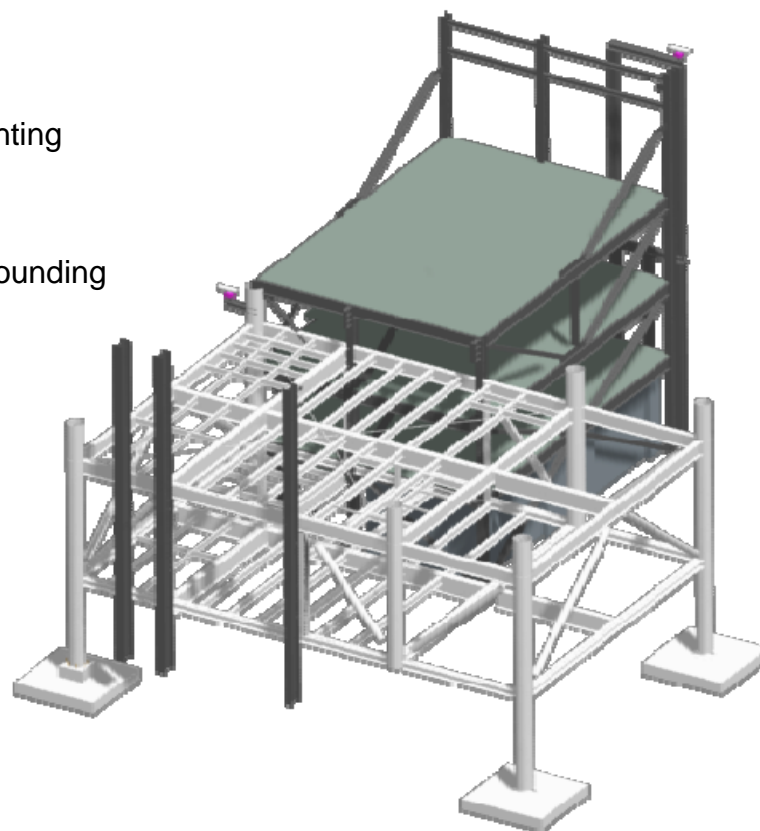


Launch Simulation Towers

- ◆ **60' North Tower and 40' East Tower in the LETF with Mobile Launcher Simulators allow the structural attachment of umbilical and access arms to perform qualification testing with the Vehicle Motion Simulator.**



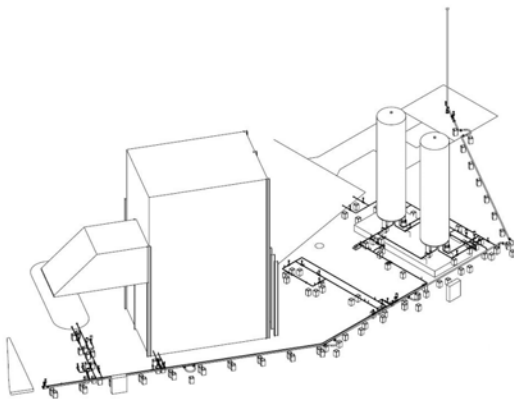
- Personnel lighting
- Flood lighting
- Power
- Bonding & grounding





Cryogenic System

- ◆ The Cryogenic System provides support for GSE, component and umbilical development and qualification testing.
- ◆ The cryogenic system consists of on site liquid Nitrogen storage, connections for tanker delivery of liquid Hydrogen, piping, valving and control devices.
- ◆ The system can provide both LN2 and LH2 to the VMS and to test area.
 - Test area has provisions for both a 2" diameter and a 8" diameter pipe spool for testing multiple sizes of components.
 - The LN2 system is comprised of two (2) 15,000 gallon cryogenic Dewars, a fifty gallon-per-minute (gpm) centrifugal pump, and vacuum jacketed supply and return piping.
 - LN2 recirculation capability
 - Test duration >24 Hours





Data Acquisition System

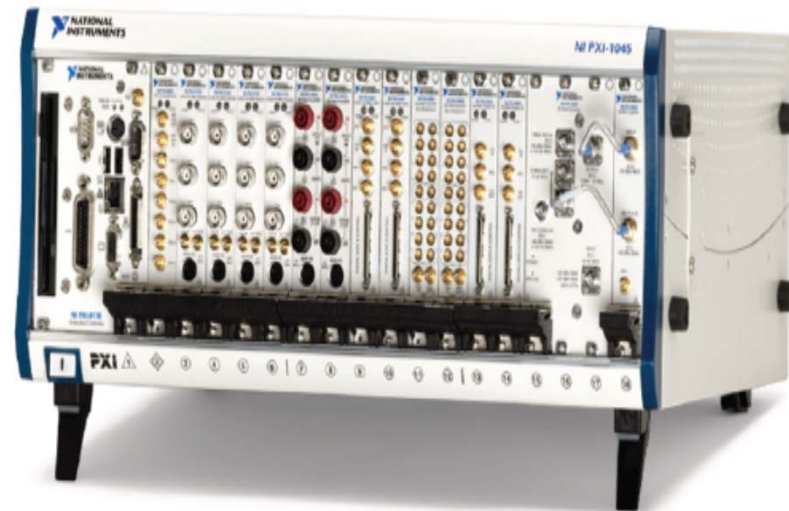
- ◆ **Data Acquisition System will condition, acquire, and archive transducer signals (i.e., temperature, pressure, strain, displacement, vibration) from program specific test articles and LETF test fixtures during testing efforts.**
- ◆ **Cable plant consisting of 604 cables (expandable to 944)**
- ◆ **352 input channels to Signal Conditioning Amplifiers / PXI Chassis**
- ◆ **160 Channels of Pacific Model 9355 Signal Conditioning Amplifiers**
 - Supports inputs from: low level bridge type (ΔR), low level voltage (ΔV), low level current (ΔI), and ICP Pressure/Accelerometer/Force sensors.
 - Software programmable gain (max 10K), excitation (0-15 & 28 VDC), filter (8 steps from 10HZ to wideband), cal steps (4 total), bridge balance, etc
 - 100KHz bandwidth (at gains up to 1000)
 - Constant voltage & current excitation





Data Acquisition System

- ◆ Four each, 18 slot National Instruments PXI-1045 chassis will be utilized to support 352 channels of Analog to Digital Converters.
 - 240 channels of low-speed sensor channels (PXI 6133, 14 Bit, 3 MS/s max, 32M/ buffer) approximately 10 seconds of recording at full sample rate.
 - 48 high-speed channels (PXI 5105, 12 Bit, 60 MS/s max, 128M/ buffer) approximately 2 seconds of recording at full sample rate.
 - 64 discrete inputs (PXI 6534, 20MS/s max, 32M/ buffer) approximately 2 seconds of recording at full sample rate.



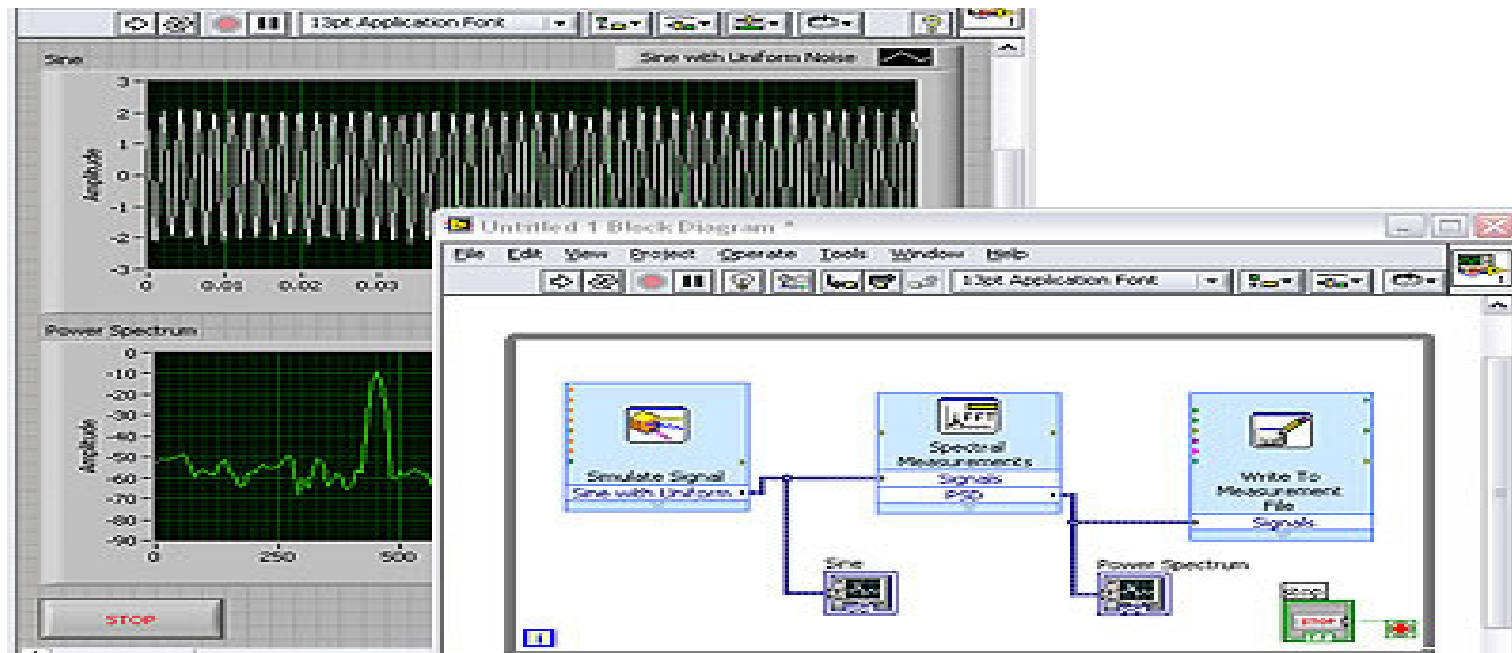
Data Acquisition System (DAS)

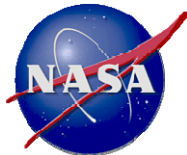


Data Acquisition Software

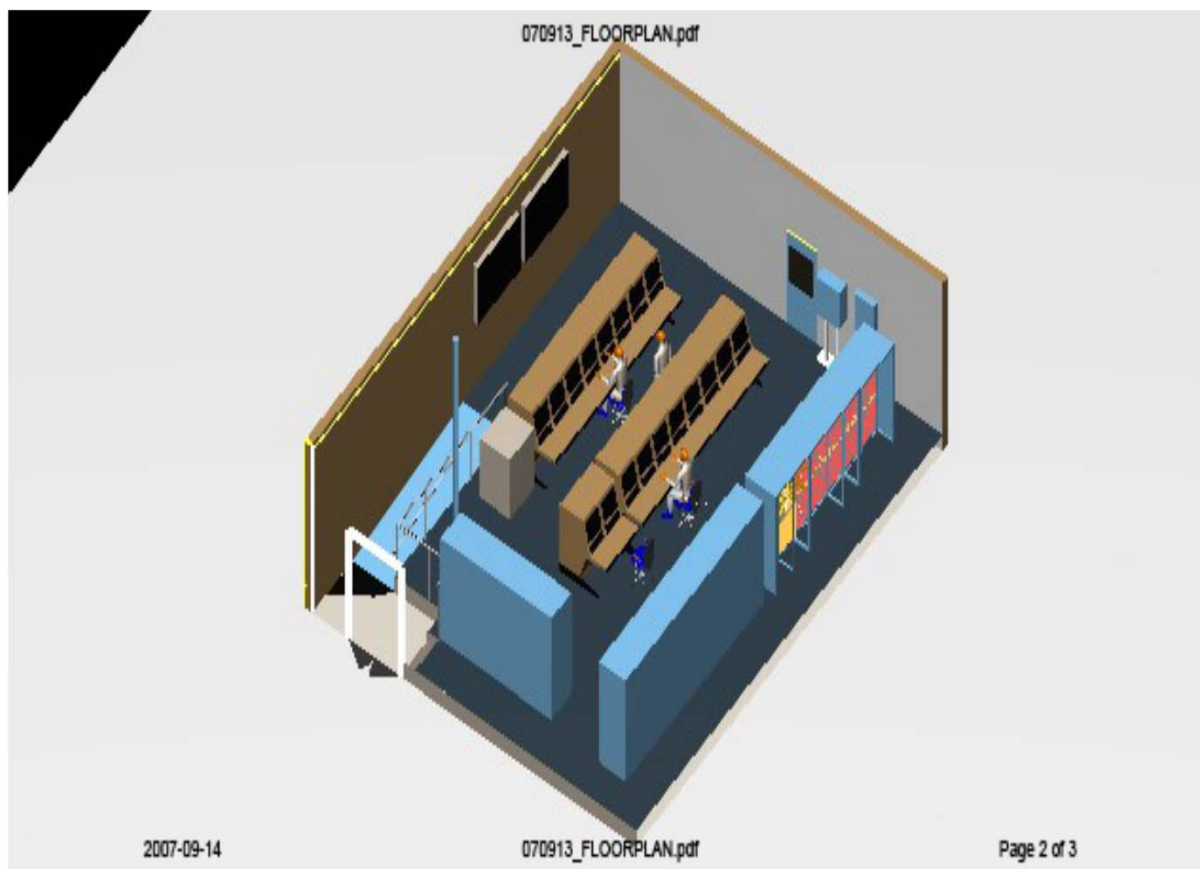
◆ National Instruments LabVIEW

- Easy-to-use graphical development environment
- Tight integration with a wide range of measurement hardware
- Rapid user interface development for displaying live data
- Extensive signal processing, analysis and math functionality
- OPC Connectivity allows integration of facility PLC sensor data into test files





Control Room Layout



•Control room supports hazardous testing/operations:

- Video System
- Data Acquisition System
- Hazardous Gas Detection System
- VMS controls
- LH2/LN2 Controls
- Pyrotechnic tests
- Test Team Communication System (OIS-M)



Fast Response Instrumentation Trailer



- ◆ **Maximum of 96 channels**
- ◆ **60 low level (Signal Conditioned) inputs and 36 direct inputs**
- ◆ **Sample rates from 1 to 3 Mega Samples/second simultaneous**
- ◆ **National Instruments PXI based Data Acquisition System**
- ◆ **Mobile, self contained control room**
- ◆ **Operates off facility power or generator power**



Video System

- ◆ **System will provide remote controlled surveillance and monitoring of test operations at various locations throughout the LETF.**
- ◆ **System is compatible with current NASA and KSC digital video standards and systems.**
- ◆ **Multi-Image Display System allowing simultaneous display of all video images on two large screens in the LETF Control Room. Video also displayed on test console monitors.**
- ◆ **The system will record and archive test images.**
- ◆ **Ten integrated pan, tilt, & zoom camera stations.**
 - 6 fixed camera locations
 - 4 mobile units
 - NEMA 4X pressurized enclosures
 - 360 degrees Pan & 180 Tilt capability
 - 16X zoom lenses for mobile cameras
 - 20X zoom lenses for fixed locations





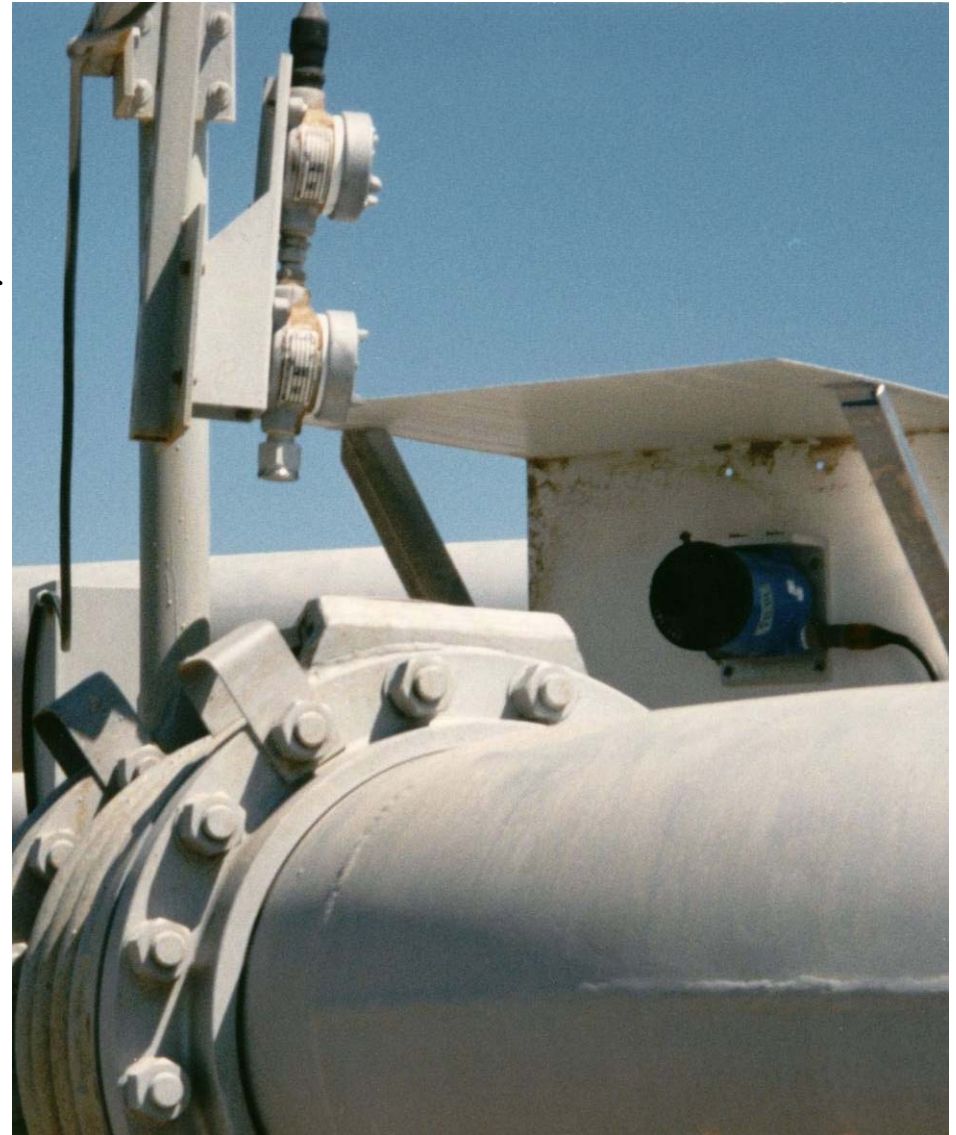
Hazardous Gas Detection System

◆ Hydrogen Fire Detection Subsystem (HFDS)

- Mandatory for LH2 Flow
- Multi-spectral infrared sensor instead of ultra-violet (means lower false positives)

◆ Ground Hydrogen Leak Detection Subsystem (GHLDS)

- Mandatory for LH2 Flow
- Primary Hydrogen Safety Systems
- LD is catalytic bead sensor





GSE Integration Testbed

- ◆ Provides fiber optic ControlNet and EtherNet communication path between the EDL and LETF.
- ◆ End-to-end testing of Command and Control software.
- ◆ Perform GSE End Item and component level qualification that require an interface to KGCS.
- ◆ Perform GSE End Item software/hardware testing & qualification on large GSE end items.
- ◆ Provide GSE end item emulation/simulation for up to 300 inputs/outputs System Description
- ◆ LabView system that is part of the GSE Integration Testbed is a very high speed data acquisition system which will provide data logging and analysis of test results when a GSE component test is performed
- ◆ The system will provide the capability to perform automated duty cycle testing and high speed logging of the test data from required GSE components



Data Acquisition Systems (DAS) Lab

The LETF Data Acquisition Systems (DAS) Laboratory is located in rooms 1307 and 1313 of building M7-505. This lab is utilized to develop, install, and maintain measurements and associated data acquisition systems required to record data for testing at the LETF. DAS Lab personnel are responsible for maintenance of the LETF Control Room, the LETF cable plant, LETF portable data acquisition systems (PDAS), and measurement and equipment calibrations. The lab is also utilized for electronic circuitry development and computer support.

Capabilities:

Complete instrumentation facilities, including:

- Surface mount soldering
- Regular through-hole soldering
- Electric prototyping
- National Institute of Standards (NIST) traceable instrumentation
- Shop air and vacuum available

Selection & assembly of computers for the following:

- Testing
- Development
- Support





Cable Fabrication & Molding Shop

The LETF Cable Fabrication and Molding Shop is located in the Northeast corner of building M7-505. This shop is utilized to fabricate KSC and Military specified electrical and instrumentation cables for the LETF, KSC, other NASA and Government facilities, and for commercial industry.

Capabilities and Specifications:

- 7-Ovens for Potting & Molding
- Fabrication of all types & grade of cables
- Installation of Crimps
- Soldering
- Installation of harnesses
- Fabrication from OIS cables to power cables
- Multiple 100psi compressed air drops throughout cable shop





Pneumatics Shop

The LETF Pneumatics Shop is located in room 1140 of building M7-505. This lab is utilized to fabricate, install and maintain pneumatic and hydraulic systems for the LETF, KSC and other Government facilities. The lab personnel also fabricate, install and maintain gas pressure control panels, calibrate pressure gages and hydrostat high pressure lines and systems.

Capabilities:

- Fluid component test bench
 - Automated valve qualification testing (relief, check and shut off valves)
- Calibration of hydraulic and pneumatic systems up to 9,000 psi
- Fabrication to KSC specifications
- Tubing
- Flex Hoses
- 1/4" – 2" tube flaring
- The ability to rebuild valves & cryo systems
- Hydrostat systems up to 9,000 psi





Machine Shop & Weld Shop



Description:

Complete machining and fabrication facilities, including computer numerically controlled (CNC) vertical mills, lathes and 5-axis wire EDM, tube bending, flaring and orbital welding up to 2" diameter. Welding capabilities include sheet metal, structural and piping, most materials and processes. The shop can take CAD files and generate tool profiles allowing rapid prototyping.

Capabilities:

Details are as follows:

- 84.1 ft x 92.1 ft (~7745 sq ft of floor space)
- Shop Break Room Mezzanine (30 ft X 25 ft)
- East roll up door – 16 ft X 18 ft
- Tool Crib Mezzanine (20 ft X 30 ft)
- Machine Shop Roll Up Doors
- East roll up door – 16 ft X 18 ft
- West roll up door - 16 ft X 18 ft

Complete machining and fabrication facilities, including:

- Computer numerically controlled (CNC) vertical mills
- Lathes
- 5-axis wire Electrical Discharge Machining (EDM)
- Punch Press
- Orbital welding up to 2" diameter
- 3 Axis Mill
- Plasma Cutter

Welding capabilities including (Tig & Mig):

- Aluminum
- Sheet metal
- Structural and piping
- Most materials and processes



LETF Highbay



Description:

The LETF Highbay is a general purpose test and development area located on the southeast corner of building M7-505. The Highbay is also utilized to assemble and stage GSE equipment to be tested in the LETF. The Highbay has been partitioned off into 8 work foot-prints. The Highbay is outfitted with an overhead crane, multiple access doors, multiple AC power availability, and shop air and storage areas. The Highbay is also an environmentally controlled area.

Capabilities:

Details are as follows:

- 100ft x 60ft (6000 sq ft of floor space); 6" foundation
- Two 10 ton overhead bridge cranes – 20T capability (41'-11" span; ~ 40' to hook)
- 600 ft² Auxiliary Control Room in Highbay to monitor operations
- East and West Main doors - 40 ft high X 30 ft wide
- South roll-up door 16 ft x 18 ft
- FP's 1-4 offer standard single phase 115v AC 20amp power source along with filtered and regulated shop air.
- FP's 6-8 offer 3phase 208 and 480v AC disconnects serviceable to 100Amp service in addition to single phase 115Vac 20amp power receptacles and shop air.
- 2 Mezzanine's approximately 400sq ft each. (Storage capabilities 250 lbs/sq ft)



LETF Contact Information

- ◆ ***NASA LETF Manager/Jeff Crisafulli***
321-867-4235
- ◆ ***ESC LETF Manager/Rick VanGilder***
321-867-2526